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# FOREST PEST MANAGEMENT

BIOLOGICAL EVALUATION
R2-92-04

## STATUS AND TRENDS OF MOUNTAIN PINE BEETLE POPULATIONS IN THE BEAR MOUNTAIN AND WHITE HOUSE GULCH AREAS ON THE HARNEY RANGER DISTRICT, BLACK HILLS NATIONAL FOREST, SOUTH DAKOTA

MARCH 1992

United States Department of Agriculture
Forest Service
Forest Pest Management
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## ABSTRACT

Increasing and epidemic populations of the mountain pine beetle, Dendroctonus ponderosae Hopkins (Coleoptera: Scolytidae) were detected and evaluated in the southcentral Black Hills. Mortality of ponderosa pine, Pinus ponderosa Dougl. ex Laws., in the area increased each year since 1988 and was six times greater in 1991 than in 1989. Survey results indicate an average of 29 trees killed per acre by this bark beetle from 1989 through 1991 in the Bearhouse project area. Infestation is especially concentrated in the Bear Mountain Basin area, where between 27 and 103 trees per acre have been killed, and a large beetle population is expected to emerge in August 1992. Bark samples of overwintering larvae collected from 54 trees at 11 sample sites averaged 23% live brood; heavy winter kill of larvae was apparent. Live brood averaged 7.6 per 0.25 sq. ft. overall, but ranged from 1.5 to 18.8 per 0.25 sq. ft. for different plots. In August 1992, populations of MPB are expected to remain stable or decline slightly at most sites, while at least a couple sites are expected to increase potentially as much as 2-fold. Stands throughout the evaluated area have a moderate to high risk of attack by mountain pine beetle and are near or within areas currently under moderate to severe beetle pressure. Strategies to mitigate the impact of this epidemic are proposed.

## INTRODUCTION

The mountain pine beetle (MPB) is the most aggressive pest affecting pines throughout the western United States, killing millions of trees each year. In the Rocky Mountain states, MPB accounts for about 77% of all mortality in pines and about 38% of the roundwood products output from sawtimber (Green and Setzer 1974). MPB is a native insect, first described from the Black Hills (Hopkins 1902). Populations of MPB persist at endemic levels, defined as less than one infested tree per acre per year (Lessard 1982), by killing and reproducing in stressed or weakened pine trees. Triggered by factors not yet fully understood, MPB populations erupt and change to an increasing phase, defined as more than one infested tree per acre per year with less than 10% of a stand infested over a three year period. Should favorable conditions persist, an epidemic phase ensues, when over 10% of a stand is infested over a three year period. At such times, healthy trees that would otherwise escape from or resist MPB attack are killed. In this way, MPB operates as a major driving force in the dynamics of western pine forests.

In the Black Hills, the first recorded MPB epidemic occurred in 1895. By 1908, 1-2 billion board feet of ponderosa pine had been killed. Four major outbreaks have occurred subsequently, each lasting 8-13 years. Peak years were in 1939, 1949, 1963, and 1974 (Lessard 1986). Succeeding outbreaks were increasingly severe; from 1969-1981, 200-300 million board feet were lost (Lessard 1986). Generally, the most susceptible ponderosa pine stands have 75% or more of the trees in the 7-13 inch diameter range and a stand density over 120 square feet basal area per acre (Stevens et al. 1980; Schmid and Mata 1992). MPB has the potential to kill 80% of the trees in susceptible stands over the course of an epidemic. Because of the relationship between stand conditions and MPB risk, the Black Hills National Forest undertook a large-scale effort to thin stands across the northern hills during the 1970's, in hopes of reducing susceptibility of pines to attack by MPB.

Aerial surveys of the Black Hills National Forest performed by the Rapid City Service Center staff, Forest Health Management, detected increasing tree mortality attributed to MPB activity in the Bear Mountain area of the Harney Ranger District from 1989 to 1991. In late 1991, a request for assistance was received from the district to assess the situation, especially on the eastern slope of Bear Mountain and adjacent lands to the east roughly bounded by Copper Mountain, Medicine Creek and White House Gulch (designated as the Bearhouse Project area; see Fig. 1). Previously contracted timber sales had not been harvested, leaving the Bearhouse area with stands at moderate to high risk in the presence of an apparently increasing MPB population. The Bearhouse Project Area has been proposed for vegetation management designed, in part, to mitigate the current and potential impacts of MPB. The purposes of this biological evaluation are to quantify past MPB activity, evaluate its current status, and predict MPB trends for 1992 in the Bearhouse area, in order to assist in the forest management decision-making process.

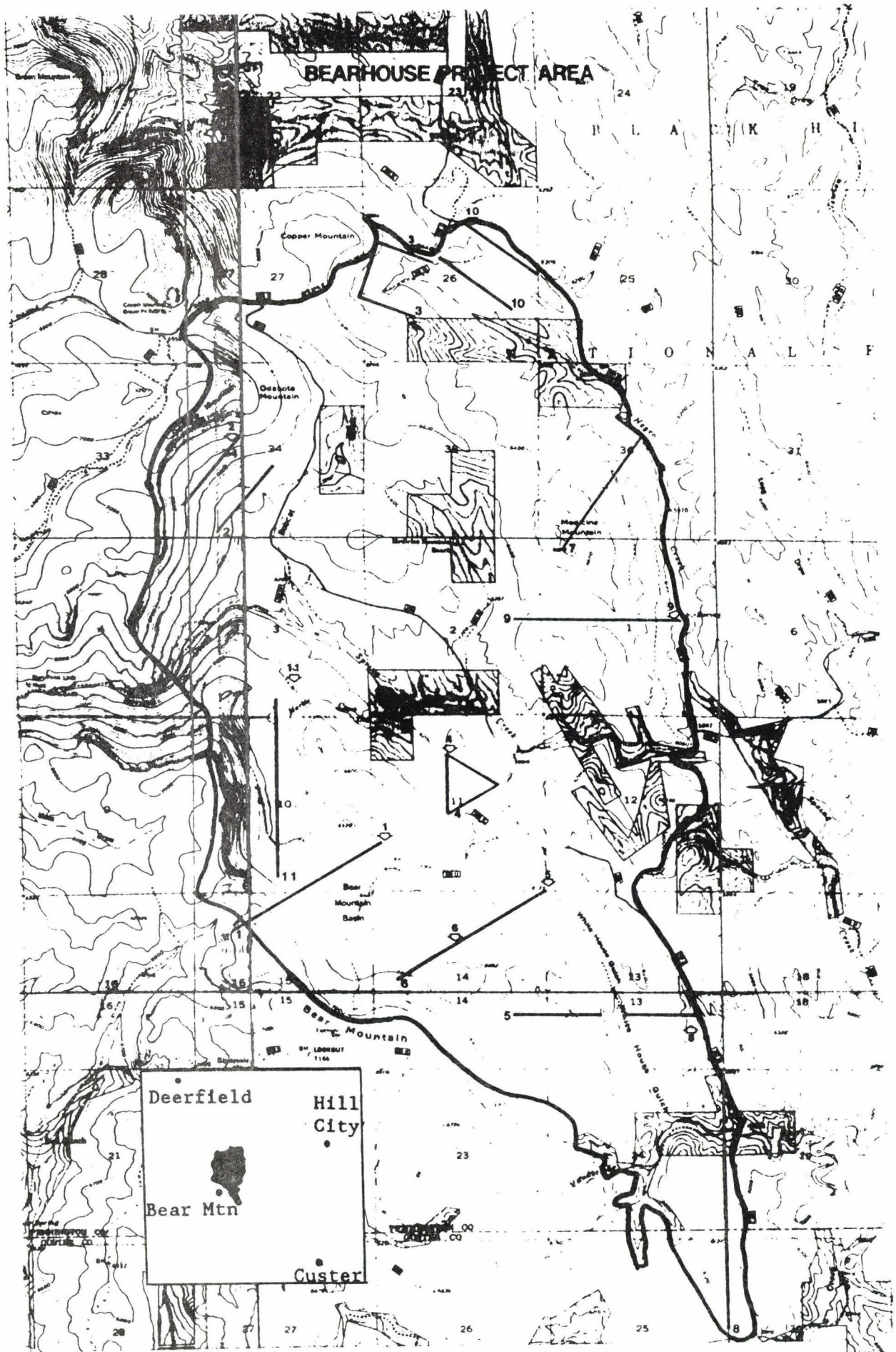


Fig. 1. Locations of survey cruise lines (numbered at the southwest extent) and brood plots (shown by numbered arrows) for 1992 mountain pine beetle survey, Harney Ranger District, Black Hills NF.

## METHODS

Aerial survey missions were flown covering the entire Black Hills National Forest in late August 1989-1991. Areas of ponderosa pine displaying the characteristic red foliage caused by bark beetle (MPB and Ips spp.) attack during the preceding year were sketch mapped onto 0.5":1 mi. forest maps as current tree mortality. Affected acreages and numbers of dead trees were estimated from sketch maps.

Ground surveys were used to assess the current and past extent of MPB activity. Cruise lines one chain (66 feet) wide by one mile long were installed in February 1992 in cutting units identified on existing forest inventory maps. Along each line, all ponderosa pine trees attacked by MPB within the past three years were located and classified by current status (live or dead), year of attack (1989, 1990 or 1991), and diameter at breast height (DBH) to the nearest inch. To confine the survey within important forested areas, some cruise lines were fragmented into two or three linear segments. A total of 11 cruise lines were walked, covering 88 acres of forest within the 5,100 acre Bearhouse Project area (Fig. 1).

Bark samples containing immature MPB (brood) were used to evaluate the potential adult beetle population that will emerge and attack trees in late summer 1992. Using a 10-BA prism, variable plots were established as close to cruise lines as possible in areas containing currently-infested trees. All ponderosa pines alive prior to 1989 were classified by current status (live or dead), presence of MPB attacks, year of attack, and DBH to the nearest 0.1 inch. Five ponderosa pines that were successfully colonized and currently infested by MPB were selected for sampling at each plot. Square bark samples, six inches per side, were removed from the north and south sides of each sample tree, for a total of 10 bark squares per plot. Each bark square was examined, and data on the following variables were tallied: egg gallery starts, inches of egg gallery length, MPB eggs, live MPB larvae (brood), dead MPB larvae, live and dead bark beetle predators including life stage and identity, insect parasites of bark beetles, and any associated bark beetles such as Ips spp.

Means with standard deviations were calculated for each cruise line and brood survey plot and for all lines or plots combined. Because each cruise line covered eight acres, tree tallies could be readily converted to numbers per acre. Various summary statistics were calculated from the data and are explained where presented.

## RESULTS AND DISCUSSION

Generally, amounts of tree mortality by year of MPB attack as determined from line surveys indicate that MPB populations are at increasing or epidemic levels across most of the project area; however, levels of damage vary widely from site to site (Tables 1 & 3). Over half of the ponderosa pines killed by MPB since 1989 were attacked in 1991 (Table 1) and will not begin fading to yellow or red foliage until summer 1992. Each year since 1989, the number of trees

killed by MPB has increased, as shown by the ratios of attack frequency between years (Table 1). This trend also is evident in initial estimates of damage generated from aerial survey data for the South Dakota portion of the Black Hills National Forest (Table 2), which reflects MPB activity predominantly within the Harney Ranger District. In addition to showing increasing MPB activity in and around the Bearhouse area, aerial surveys indicated an apparent spread of MPB activity from the Bearhouse area toward the west and north.

Since 1989, a project-wide average of 29 trees were killed per acre. Trees attacked in 1991 ranged from 0 at Medicine Creek to 61.4 per acre in line 6 at Bear Mtn. Basin (Table 3). The four cruise lines (6, 1, 4, 11) with the greatest number of trees killed in 1991 ("green dead") are in or immediately adjacent to Bear Mountain Basin (Table 3). This area on the northeastern slope of Bear Mountain is under severe pressure from MPB, with perhaps 80% of the trees already killed (total dead of green, red, and grey tops). The concentration of trees attacked in 1991 in this area may be greater than indicated by the survey line averages. For example, 98% of 1991-attacked trees on line 6 were found on the Bear Mountain Basin end rather than being evenly distributed out to White House Gulch. Similarly, 70% of 1991-attacked trees were found along the southern half of line 11 (see Fig. 1 for line locations). On line 5, the western half contained 83% of all attacked trees; therefore, survey figures are more indicative of infestation levels at the western edge of Bear Mountain than the lower elevations of southern White House Gulch.

A second group of cruise lines with populations of MPB at increasing to epidemic levels is located to the northeast of Bear Mountain, from the northern portion of Medicine Creek to the southwest slope of Copper Mountain (cruise lines 7, 10, and 3). Currently, this area supports moderate to high MPB populations. Although many green, uninfested trees remain, they are prime targets for future attack because of the presence of a large beetle population and suitable host and stand conditions.

A third group of cruise lines (2, 8, 9) had MPB populations at endemic levels. Cruise line 2 on Odakota Mountain was located in an open, recently logged area. The only MPB-killed trees detected on line 2 were located on the northeast end, just beyond the timber sale boundary. The absence of attacks in the logged stand lends circumstantial evidence to the assertion that lower density stands incur fewer MPB attacks, a result confirmed by recent research in the area (Schmid and Mata 1992). Cruise lines 8 and 9 had few attacked trees per acre; however, tree mortality caused by MPB was observed in the vicinity. While driving a two-mile stretch of USFS Rte. 273 on the eastern boundary of the Bearhouse Project Area from south of Van der Lehr Creek north to the junction with USFS Rte. 299, 8 MPB-caused mortality spots of red-topped trees were detected by casual observation to the west of the road.

**Table 1.** Tree mortality and failed attacks from mountain pine beetle along 11 cruise lines in the Bearhouse Project Area, Harney Ranger District, Black Hills National Forest (February, 1992; numbers are means ± standard deviation unless indicated).

**NUMBERS OF TREES ATTACKED**

| Year | Total Trees Attacked (88 acres) | Attacked Trees Per Survey Line (8 acres) | Attacked Trees Per Acre |
|---|---|---|---|
| 1989 Dead | 235 (9%) | 21.3 (± 27.7 ) | 2.7 (± 3.5 ) |
| 1990 Dead | 752 (29%) | 68.4 (± 87.5 ) | 9.3 (± 10.9 ) |
| 1991 Dead | 1341 (53%) | 121.9 (± 163.3 ) | 15.2 (± 20.4 ) |
| Failed 1991 Attacks | 227 (9%) | 20.6 (± 29.2 ) | 2.6 (± 3.6 ) |
| ALL DEAD | 2326 (91%) | | |
| ALL ATTACKS | 2553 (100%) | 232.1 (± 287.8 ) | 29.0 (± 36.0 ) |

**RATIO OF ATTACK FREQUENCY BETWEEN YEARS**

1989:1990 -- 1:3

1990:1991 -- 1:2

1989:1991 -- 1:6

**Table 2.** Aerial survey estimates of ponderosa pine mortality from bark beetles (mountain pine beetle and *Ips* spp.) in the South Dakota portion of the Black Hills National Forest.

| Year Attacked | Year Detected | Acres Infested | Number of Dead Trees |
|---|---|---|---|
| 1988 | 1989 | 2,400 | 6,900 |
| 1989 | 1990 | 6,720 | 12,060 |
| 1990 | 1991 | 10,879 | 33,271 |

**Table 3.** Ponderosa pine trees attacked by mountain pine beetle in the Bearhouse Project area, Harney Ranger District, Black Hills National Forest (Winter, 1992), listed by cruise line (8 acres/line) in descending order of 1991 infestation severity. Unsuccessful attacks are included in the total.

| Line Number | Line Location | Killed Trees Per Acre, Attacked in 1991 | 1990 | 1989 | TOTAL Attacked |
|---|---|---|---|---|---|
| 6 | Bear Mtn Basin | 61.4 | 36.4 | 5.0 | 114.4 |
| 1 | Bear Mtn Basin | 41.6 | 10.0 | 9.8 | 61.6 |
| 4 | Bear Mtn Basin (Spring Creek) | 26.1 | 20.0 | 8.3 | 61.9 |
| 11 | Bear Mtn Basin | 21.1 | 5.0 | 0.4 | 28.9 |
| 7 | Medicine Creek | 8.4 | 6.3 | 1.9 | 18.8 |
| 10 | Copper Mtn | 3.6 | 1.0 | 1.4 | 6.6 |
| 3 | Copper Mtn | 2.1 | 9.3 | 0.9 | 12.9 |
| 5 | White House Gulch | 1.9 | 4.9 | 1.8 | 9.8 |
| 2 | Odakota Mtn (Logged) | 1.3 | 0.1 | 0 | 1.5 |
| 8 | Van der Lehr Creek | 0.1 | 0.4 | 0 | 1.3 |
| 9 | Medicine Creek | 0.0 | 0.8 | 0 | 1.6 |

It is difficult to develop an accurate description of MPB activity throughout the Bearhouse Project area based on 11 line surveys due to the variability caused by the clumped and irregular distribution patterns of MPB attack. New attacks tend to expand from existing focal points of infestation; long-range, scattered dispersal of adults is generally thought to be much less common as long as suitable host material is available in the area of an epidemic. Cruise line data provide an illustration of this. Data on numbers of trees killed per acre for each year were ranked and compared between years using Spearman's correlation coefficient. The results indicate a statistically significant association of infestation severity between years. Correlation coefficient values were as follows: 1991 with 1990 = 0.873; 1990 with 1989 = 0.841; and 1991 with 1989 = 0.832. The probability of obtaining this array of ranks due to chance alone is much less than 0.5% for each comparison. For a given year, MPB tree mortality along the cruise lines was strongly and positively correlated with mortality in the preceding one to two years.

Practically all brood identified in bark samples from 54 trees (N = 108 samples; only 4 trees were sampled in brood plot 3), were in the larval stage, the normal overwintering phase of MPB. Only three MPB eggs were found and probably were not viable. Total brood (live and dead larvae) produced per inch of egg gallery, was relatively consistent across most sample plots, averaging close to one (Table 4). The notable exception was brood plot 6 in Bear Mountain Basin, which produced almost twice as many larvae per gallery inch as the average for all plots. Females constructed a mean of 36.6 inches of egg gallery per sample. Therefore, overall brood production following egg and early larval mortality and prior to winter mortality approximated 37 larvae per 0.25 sq. ft. sample.

Of the total brood, 23% were alive and the rest were dead (Table 4). By plot, live brood ranged from 6-48%, indicating that heavy brood mortality occurred on some plots (Table 4). However, a sizeable MPB population remains to fuel a continuing epidemic. Overall, brood production averaged 7.6 live larvae per 0.25 sq. ft. sample.

Dead larvae in bark samples were discolored and darkened as is characteristic of brood killed by low temperatures. An early snowstorm in late October 1991 may have affected many larvae before they had a chance to become physiologically adapted to surviving extreme winter conditions. Weather is a major factor affecting overwintering survival of MPB brood (Knight 1959).

A moderate, statistically significant linear relationship was detected between % live brood and the diameter at breast height (DBH) of the 54 brood sample trees. This relationship was modeled as follows: % live brood = $-0.4642 + 0.0569(\text{DBH})$; $r^2 = 0.36$; $p < 0.005$. Increased percentages of live brood were associated with larger diameter trees. This result is likely due to larger trees having thicker phloem, providing more food for MPB brood, and thicker bark, providing greater thermal insulation and protection from natural enemies.

**Table 4.** Overwintering brood of the mountain pine beetle with plot description and reference to nearest cruise line, sampled February 1992, in the Bearhouse Project area, Harney Ranger District, Black Hills National Forest. Brood plots are listed in order of infestation severity for 1991 MPB attacks along the nearest cruise line. Numbers following ± are standard deviations.

| Brood Plot No. | Nearest Cruise Line No. | Basal Area (sq. ft.) | Diameter at Breast Ht. of Plot (in.) | Total brood per Gallery Inch * | Live Brood per 0.25 $ft^2$ | % Live Brood | Population Index (live brood per gallery start) |
|---|---|---|---|---|---|---|---|
| 6 ** | 6 | 190 | 10.2 ± 2.4 | 2.0 ± 1.0 | 9.3 ± 6.6 | 15% | 4.04 |
| 5 ** | 6 | 150 | 10.8 ± 1.7 | 0.8 ± 0.4 | 4.8 ± 4.6 | 20% | 2.18 |
| 1 | 1 | 100 | 10.3 ± 1.6 | 0.7 ± 0.6 | 2.8 ± 3.9 | 10% | 1.22 |
| 4 | 4 | 100 | 13.7 ± 3.1 | 1.0 ± 0.8 | 18.8 ± 25.5 | 46% | 10.44 |
| 11 | 11 | 150 | 8.8 ± 3.3 | 0.8 ± 0.3 | 6.4 ± 4.6 | 24% | 2.78 |
| 7 | 7 | 170 | 9.3 ± 2.4 | 0.9 ± 0.8 | 18.2 ± 22.3 | 48% | 10.71 |
| 10 | 10 | 250 | 11.9 ± 2.9 | 1.1 ± 0.8 | 3.5 ± 3.7 | 10% | 1.94 |
| 3 | 3 | 130 | 8.7 ± 3.7 | 0.7 ± 0.3 | 1.5 ± 1.7 | 7% | 0.75 |
| 8 | 5 | 130 | 9.1 ± 1.9 | 0.9 ± 0.8 | 10.5 ± 13.4 | 31% | 4.38 |
| 2 | 2 | 170 | 10.5 ± 2.3 | 1.0 ± 0.3 | 2.9 ± 4.8 | 6% | 1.38 |
| 9 | 9 | 140 | 10.6 ± 2.8 | 0.8 ± 0.5 | 5.0 ± 5.8 | 21% | 3.85 |
| ALL 11 Plots | | 160 ± 40 | 10.4 ± 1.5 | 1.0 ± 0.4 | 7.6 ± 6.0 | 23% | 4.09 ± 3.73 |

* average gallery inches per 0.25 sq. ft. = 36.6 (± 3.3)

** Plots 5 (White House Gulch) and 6 (Bear Mtn. Basin) were both located near line 6; no plot was established near line 8 because no infestation spot was located.

Mortality of brood caused by other factors such as competition between larvae are not readily apparent during winter sampling. Larvae that die early in their development from predation, starvation, competition, or other factors, generally are not detectable. However, some natural enemies can be detected. Disease was not identified as a cause of larval mortality. An average of 1.5 bark beetle predators were found per sample, of which 85% were alive. A total of two insects parasitic on bark beetles were found. These natural enemies likely killed relatively few MPB. Woodpecker activity was noted in nearly all brood plots and along cruise lines, indicating that they are taking advantage of the abundant food source. Despite the visibility of their feeding activity, woodpeckers typically play a minor role in regulation of MPB populations. Between the time of sampling and adult emergence in July or August, additional mortality in the '91-'92 MPB generation is expected, particularly among brood due to biotic factors such as natural enemies (parasites, woodpeckers), but is not likely to be sufficient to halt the course of the epidemic. Brood samples taken in late June rather than February could provide more consistently reliable indications of population trend (Knight 1959). However, such predictions would come far too late in the MPB generation to be of much use in the forest management decision-making process. The winter sampling does provide an indication of the health and magnitude of the existing beetle population.

Approximately 96% mortality of MPB brood was estimated for the '91-'92 generation through February using Knight's (1959) calculation methods. This mortality percentage is somewhat higher than those reported by Knight (1959) for a similar stage of the MPB life cycle (about 67-83% depending on intensity of infestation). The high reproductive potential of MPB permits populations to increase dramatically even after greater than 90% mortality occurs within a generation, and populations begin to decline only after generation mortality exceeds 99% (Knight 1959).

The number of live brood divided by the number of gallery starts indicates the numerical contribution of each female to the next generation, because MPB females are monogamous, solitary, and usually initiate one egg gallery per tree. Thus, the number of live brood per gallery start (i.e. per female) can be used as an index of population change (Table 4). Assuming numbers of male and female parents are approximately equal, 2.0 live brood per female indicates a static population where each parent is replaced in the next generation. Population index values above and below 2.0 suggest an increase and a decrease, respectively, in population size. The MPB population index ranged from a low of 0.75 at plot 3, a decrease by nearly two-thirds, to a high of 10.7 at plot 7, approximately a 5-fold increase (Table 4). Actual infestation levels in 1992 likely would be somewhat lower than suggested by the population indices due to additional mortality of brood prior to adult emergence and the loss of adults during flight, which can be a third or more of the beetles. Populations can be expected to increase on at least a couple plots, but are likely to remain static or decline on most plots sampled. There is no apparent, regular pattern of distribution to the

increasing and decreasing population centers across the Bearhouse Project area. Overall, the number of trees attacked in 1992 could potentially double relative to the number infested in 1991, but is more likely to fall somewhere between there and slightly declining levels.

The Bearhouse Project area has high levels of currently infested trees per acre, especially in the Bear Mountain Basin (Table 3). Large numbers of adult MPB will be produced there in 1992, emerging into and likely dispersing beyond the area that already has extensive mortality and few remaining green trees. The Medicine Creek area near plot and line 7 is also of high, immediate concern because of the high population index value (Table 4), the high percentage of live brood (Table 4), and the fairly high number of currently infested trees (Table 3).

Biological evaluations over the past 30 years of MPB epidemics in the Black Hills National Forest present generally similar survey results using similar methods. Several important differences are noteworthy. During previous MPB epidemics, less tree mortality resulted over fewer years in the vicinity of the Bearhouse Project area relative to areas in the northern and northwestern Black Hills. The maximum value of tree mortality previously reported in one year was 26.8 infested trees per acre on the Spearfish Ranger District during the 1973-1977 epidemic (Creasap and Minnemeyer 1976). Numbers of trees attacked in the Bear Mountain Basin area in 1991 are at or above that level (Table 4). Ratios of attack frequency between years are generally similar over large areas during population build-up, often being around 1:2, but occasionally fall in the 1:8 or higher range. The highest recorded ratio was 1:13.5 for 1975:1976 on the Nemo Ranger District (Creasap and Minnemeyer 1976). In the Bearhouse Project area, the 1990:1991 trend followed typical build-up patterns, averaging about 1:2 with a maximum on cruise line 1 of 1:4. However, MPB attack density is unusually high compared with previous figures reported by Knight (1959). The average for all brood plots was 8.0 entrance holes per square foot of bark in Bearhouse samples, whereas Knight (1959) reported an overall average of 5.0 and a 7.9 maximum. He stated that high values were a good indicator of population increase. In contrast, current live brood figures for the Bearhouse area samples were at or below the lowest values previously reported (8 per 0.25 sq. ft. at Intake Gulch; 16-17 per 0.25 sq. ft. at Rochford and Medicine Mtn. during 1976), despite those earlier samples having been examined later in the development period (late June) (Cahill and Yarger 1976). Since attack densities (mean gallery inches per unit area) were similar for 1976 and 1992 surveys, this underscores the high level of winter mortality found in the 1991-1992 brood. The high levels of currently-infested trees per acre likely offset the low brood numbers found in the Bearhouse area.

## ALTERNATIVES

Several methods are available to reduce populations of MPB and the resultant tree mortality. These pest management strategies may focus on the reduction of infested material, reduction of susceptible host material, or prevention of new attacks. No method is sufficient to entirely suppress an epidemic. The intent of forest management should be to reduce adverse impacts to the affected areas and minimize spread of the problem to adjacent stands. The decision to use a particular method should be predicated on considerations of stand conditions, location, management objectives, economic factors, other resource values, and other pertinent variables and issues.

Alternative 1: **Sanitation/Salvage Harvesting** - Fell infested trees and remove them from the site for mill processing prior to adult MPB emergence in late July and early August.

Where to use - Sites with the following conditions are appropriate: accessible to logging operations such as near existing roads or where roads can be readily constructed; less than 40% slope; where disturbance by man will not adversely affect special resource values; and in proximity to high value areas that need to be protected.

Advantages - Beetle populations can be significantly reduced in localized areas/stands by removing most or all infested trees prior to beetle emergence. Salvaging provides a degree of protection to surrounding, uninfested trees by removing a nearby source of attacking beetles, recovers timber volume that otherwise would be lost, reduces fuel load, reduces subsequent hazard from falling trees and inaccessibility to large animals, reduces visual impact of dead and dying trees, and will encourage regeneration.

Disadvantages - Short implementation time is required; trees must be removed prior to adult emergence in late July-early August of the year following attack. Adverse disturbance of the site and soil is possible. Salvaging removes tree cover in spots or at densities that may be considered adverse aesthetically. Large areas of salvage may resemble clearcuts. Disturbance and loss of cover may adversely affect some wildlife species.

Alternative 2: **Silvicultural Treatment** - To lower susceptibility in green and infested stands, stand density should be reduced to 60-80 basal area. Care must be taken during marking to avoid leaving dense pockets in a stand, as even small areas greater than 120 BA are still highly susceptible to attack and serve as loci

for continuing MPB populations. The most susceptible stands are even-aged with about 75% or more trees in the 7 - 13 inch diameter range (Lessard 1982). Stands should be thinned or harvested periodically to improve vigor and provide a more open environment that is thought to be less favored by MPB.

Where to use - This is a preventative treatment that should be incorporated as an ongoing part of the regular timber program.

Advantages - Silvicultural treatment reduces susceptibility of stands to beetle attack, which may limit tree mortality and infestation size in the future.

Disadvantages - This alternative is not suitable for sites where harvesting activity is not desirable, such as in wilderness, on steep slopes, or where visual quality would be adversely impacted.

Alternative 3: **Mechanical Control** - Fell and buck infested ponderosa pine trees and treat them by burning, peeling the bark, chipping the logs, or drenching with carbaryl (Sevin) prior to beetle emergence in July.

Where to use - Appropriate for treating small spots in areas of high concern, such as adjacent to residences. Can be used in unroaded areas or on steep slopes that are accessible on foot (or horseback) to logging but where roadbuilding or skidding is undesirable. Sites where no logging company is interested in bidding on the timber or volume is too small to put up a sale also may be appropriate.

Advantages - Much of the beetle brood can be eliminated even in the absence of a timber market. Mechanical control provides a degree of protection to surrounding, uninfested trees by removing a nearby source of attacking beetles. It also reduces subsequent hazard from falling trees and inaccessibility to large animals, reduces visual impact of dead and dying trees, and will encourage regeneration. Potential for site and soil disturbance is less than for alternative 1.

Disadvantages - Mechanical control is labor intensive, does not recover value and volume from trees, leaves a high fuel load on the site, removes tree cover, and requires a short implementation time; trees must be treated prior to adult emergence in late July-early August in the year following attack.

Alternative 4: **Protection of High Value Trees** - Prior to beetle flight in the summer (July and August), the boles of valuable trees can be sprayed with carbaryl to prevent MPB attack.

Where to use - This method would be appropriate for use in and around campgrounds and private homes. Trees must be of high value. Insecticide application is not effective for trees that have already been infested.

Advantages - Insecticide application provides a degree of protection not currently available through other mitigation strategies. Carbaryl has a low mammalian toxicity and low residual activity, which means it remains in the environment for a short period of time.

Disadvantages - Material is toxic to other insects as well as to MPB. Many citizens have concerns about environmental contamination and safety. Insecticide application does not effectively reduce the existing beetle population, is expensive if very many trees are treated, and size of treatment areas need to be small due to cost and labor considerations.

Alternative 5: **Do Nothing** - Accept tree mortality caused by MPB as a natural phenomenon.

Where to use - Use where other control alternatives cannot be effected or are not desired.

Advantages - No mechanical site disturbance or introduction of foreign materials into the environment will occur. Change in vegetation and cover may be advantageous to certain wildlife species.

Disadvantages - The no action alternative allows the beetle population to continue to increase and threaten additional sites. Tree volume and value is lost, visual quality is adversely affected by dying and dead trees, fuel load increases, tree hazard increases, inaccessibility to large animals increases with time as trees fall over, and tree regeneration is inhibited due to shading by remaining dead trees and lack of seedbed preparation.

## RECOMMENDATION

Generally, within the Bearhouse Project area, a combination of alternatives 1 and 2 is recommended. Harvesting infested trees and thinning remaining uninfested trees can be done in a single timber sale operation within a cutting unit. The ratio of sanitation/salvage cutting to thinning will vary greatly from stand to stand in relation to the level of MPB activity at the time of harvesting. Areas can be prioritized based upon the current MPB beetle populations. Emphasis should be placed upon sanitation/salvaging of timber in the Bear Mountain Basin area prior to mid-July 1992 if feasible. The identification of a sizeable concentration of beetles overwintering in this location provides an opportunity to eliminate a significant proportion of the existing MPB population in the Bearhouse area. Because few uninfested, green trees remain in this area, beetles can be expected to disperse widely and in an unpredictable manner to surrounding stands if harvesting does not occur prior to the July-August 1992 beetle emergence period. The Medicine Mountain/Copper Mountain area should be given priority for treatment in fall/winter 1992 because there is heavy beetle pressure in the area, but many green, uninfested trees remain (although additional MPB attack is expected in 1992) that could benefit by a reduction in stand susceptibility. Other stands within the Bearhouse Project area and in nearby timber sale areas should be harvested beginning as soon as feasible, primarily to thin them so they are of low risk to MPB attack, but also to remove pockets of infested trees.

Because no campgrounds or other high value sites are located on Forest Service land within the Bearhouse Project area, alternatives 3 and 4 are not recommended. However, these alternatives should be considered by private landowners for sites located within or near the infested area.

The no action alternative generally is not recommended (with a few exceptions, such as protecting a goshawk nesting area) because of the magnitude of potential adverse impacts on a variety of resource values, the emphasis on timber production (7A management designation) in a majority of the affected area, and the proximity to private land where action has been proposed.

## ACKNOWLEDGMENTS

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